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Report to the Government

of

THE PHILIPPINES

on

CONTROL OF ABACA MOSAIC

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

ROME, 1957

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REPORT

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CONTROL OF ABACA MOSAIC

by

C. J. Magee,
Plant Pathologist

Rome, 1957

FAO/57/5/3595

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INTRODUCTION

In accordance with the request of the Government of the Philippines for technical assistance in the control of abaca mosaic, the Food and Agriculture Organization of the United Nations, under its Expanded Technical Assistance Program, appointed Dr. C.J. Magee, to advise and assist the Government in the development of effective measures for controlling this disease. The expert served in the Philippines from 18 October to 21 December 1956.

Grateful acknowledgment is made of the assistance given to the expert of many members of the Department of Agriculture and Natural Resources, certain commercial companies, a number of private citizens connected with the abaca industry, and Mr. Eric. E. Ward and Staff of the United Nations, Manila. In the Department of Agriculture and Natural Resources, the Honorable Secretary, Juan de G. Rodríguez, the Honorable Undersecretary Jaimé N. Ferrer, Director Eugenio E. Cruz, Dr. Pedro S. Sales, Dr. Juan P. Torres, Mr. Faustino Q. Otanes, Mr. Marcelino Constantino, Dr. Tranquilano G. Fajardo, Mr. Epitacio A. Lanuza and Mr. Tiburcio G. Garrido, have been particularly helpful. Outstanding and cordial assistance was given the expert by Mr. Julian A. Agati, Executive Officer, Manila, and Mr. Esteban Nera, Executive Officer, Davao City, of the Abaca Mosaic Control Campaign, and members of their staff. The expert's surveys at the Southern Mindanao regional stations were greatly facilitated by Mr. Vicente Arancillo, Superintendent, and Mr. P.O. Pacambaba and staff of the Fiber Section, and Mr. Bernardo S. Castillo and staff of the Research Section, and other officers stationed at Bago Oshiro.

Assistance was received also from Professor G.O. Ocfemia and Professor Martin S. Celino of the College of Agriculture, los Baños, and Mr. Bernardo S. Castillo, who entered into discussions on the nature of the virus and history of the disease, and Mr. William F. Dickson, Chief, Agricultural Division, U.S. ICA to the Philippines and members of his staff.

In the preparation of this report Dr. Magee is greatly indebted to Mr. Honesto Velasco, artist-photographer, Mr. Triufono Adriano, Mr. Piorelio Racinez, draftsmen, and Miss Gloria Garganera for their helpful co-operation.

I. CURRENT KNOWLEDGE OF ABACA MOSAIC

The mosaic disease of abaca (Musa Textilis Née) was first recorded in the Philippines by Calinisan (2) in 1933 in the Odell Plantation, Madaum, Province of Davao. As the virus which causes abaca mosaic is relatively non-specific and affects many plants other than abaca, it is possible that the disease was present much earlier. Whether this is so or not, it appears to have spread with rapidity during the 1930's. Thus, in 1937, Mr. U. Kojima, of the Ohta Development Company, reported to Professor G.O. Ocfemia (21,10) of the College of Agriculture, Los Baños, that in some places in Davao, fully 50 percent of the abaca plants were infected with mosaic disease. In 1938, too, Calinisan (3) stated that in the Province of Davao, mosaic had developed into one of the major diseases of abaca.

1. Insect Vectors

The early attempts to transmit mosaic of abaca by means of aphids were inconclusive, but, in 1938, Ocfemia and Celino (21) were successful in obtaining transmission with Aphis gossypii and two un-identified species of aphids. Later, the same investigators (11) demonstrated that Rhopalosiphum nymphae, Aphis maidis and Rhopalosiphum prunifoliae could also act as vectors of the abaca mosaic virus. There are thus four known aphid vectors of abaca mosaic. It is probable, as suggested by Ocfemia (22), that some of these aphids are not important vectors under field conditions as they infest abaca only under conditions of stress caused by population pressure or absence of their customary hosts. Of those incriminated, the expert would judge Aphis maidis as the worst culprit because of its close association with grasses, with A. gossypii a close second because of its moderate affinity for young abaca plants. There has been a claim (7, 14) that abaca mosaic may be transmitted experimentally by the leaf hopper, Proutista moesta, and while this seems possible in view of the nature of the virus, further work appears necessary before this insect can be accepted as a vector. Attempts to transmit abaca mosaic by means of the aphid most commonly associated with abaca Pentalonia nigronervosa, have been unsuccessful.

2. Mechanical Transmission of the Virus

Although early efforts to transmit abaca mosaic by mechanical means did not succeed (3,10,15), more recent attempts, (9, 13) using modifications of the carborundum method, have been successful, and this method of transmission is now in regular use in inoculating hybrid seedlings for determination of resistance at the Southern Mindanao Regional Station, Davao. However, mechanical transmission is regarded, as unlikely to be an important means of dissemination of the virus under field conditions (13) and the expert concurs with this view.

3. Sources of Inoculum

In addition to abaca, a number of other monocotyledonous plants can harbor the virus (or strains of the virus or virus complex) which causes abaca mosaic. These are as follows:

Canna, Canna indica L. (21)

Corn, Zea mays L. (11, 13)

Panicum colonum L. (7)

Arrowroot, Marantha arundinacea L. (7, 13)

Culapé, Paspalum conjugatum Berg (9)

Crab grass, Digitaria sanguinalis (Linn.) Scop. (23)

Seedy musa, Musa spp. (7)

The relative importance of these plants as source plants or reservoirs of the virus will depend on the extent to which they occur as weeds in plantations (or as nearby crops), frequency with which they become infected with the abaca mosaic virus, and their liability to support high populations of any of the four known aphid vectors of the virus. Field observations made by the expert in Mindanao suggest that grass weeds, both because of their general occurrence and their liability to carry high populations of either Aphis maidis or A. gossypii, are the most likely to provide dangerous sources of infection. The danger arising from corn will be discussed in the body of this report.

Identity of the Virus

No decision can be made at this stage on the identity of the virus which causes or incites abaca mosaic, but no special significance should be attached to this statement as, owing to the paucity of our methods of virus classification, the same statement might be made concerning the viruses associated with many other important crop diseases. Neither should the lack of precision in classification interfere in any way with the adoption of a program of control since a great deal is known about the virus, its vectors, its mode of perpetuation and transmission, and the many plants which will harbor it. The abaca mosaic virus has been classified (10,11) as Cucumis virus or Marmor cucumeris, the name depending on whether Smith's or Holmes' system of classification is adopted. The virus is a vector-direct, non-persistent one, which is obviously strongly specialized to monocotyledons, many of them being grasses, and it is considered that on present knowledge, it would be more appropriate to place it in the grass-mosaic group of viruses, the best known member of which is the virus of sugar

cane mosaic. Such placement must, however, be regarded as purely tentative, awaiting further investigation. If a name must be given to the pathogen, it should be Saccharum virus 1 Smith or Marmor sacchari Holmes. Ocfemia, in 1949 (22), appears to have had thoughts in the same direction but he did not develop the idea further. It may be mentioned here that abaca mosaic is entirely distinct from banana mosaic or infectious chlorosis described by the expert (19, 20), in Australia. This disease is caused by strains of Cucumis virus 1 Smith, and from banana, the virus can be transmitted experimentally to abaca, tomato, cucumber, tobacco, canna, etc. that is, to both Monocotyledons and Dicotyledons. Field observations in Mindanao, too, indicate that under natural conditions, bananas are immune or highly resistant to the abaca mosaic virus.

5. Dissemination of the Virus

From the above, it will be evident that abaca is liable to contract mosaic if grown in association with certain infected grasses and other plants. It can be assumed that the risk of infection will vary with vector populations, which in turn are doubtless subject to seasonal influences. Field observations indicate that abaca is not a normal and regular host of any of the vectors and as a result, it is probable that infection of abaca is largely a matter of chance. Whether ants play a part in moving the vectors from plant to plant has not been fully established but this has been suggested (8) and is worthy of further close study. The risk of infection would be great in plantations in which infected grass weeds are common or in which maize is interplanted thereby encouraging high populations of Asphis maidis; conversely, in well managed and clean plantations, it would be low. It is considered too, on account of the virus not being persistent in the vector (10), that dissemination of the virus by vectors from areas outside a plantation is of relatively rare occurrence. Field observations support these views.

There is no evidence that abaca mosaic virus is harbored by soil, that root contact between plants is important or that the disease can be transmitted through the true seed.

It is, however, a feature of the disease that once an abaca plant becomes infected, the virus enters the corn system, and rapidly or slowly moves partially or completely throughout the system. If the movement is rapid, symptoms of the disease soon show up throughout the hill and it is now unlikely that planting stock would be chosen from such a hill. When, however, the movement of the virus is retarded there is great risk of apparently healthy, though infected, planting material being chosen. Discussions the expert has had with members of the Abaca Mosaic Control Unit have left little doubt in his mind that dissemination of infected planting stock coupled with the interplanting of corn has been responsible for much of the serious losses which have occurred and the spread of the disease into new districts. It is proposed in this report to examine means of decreasing future losses from the disease.

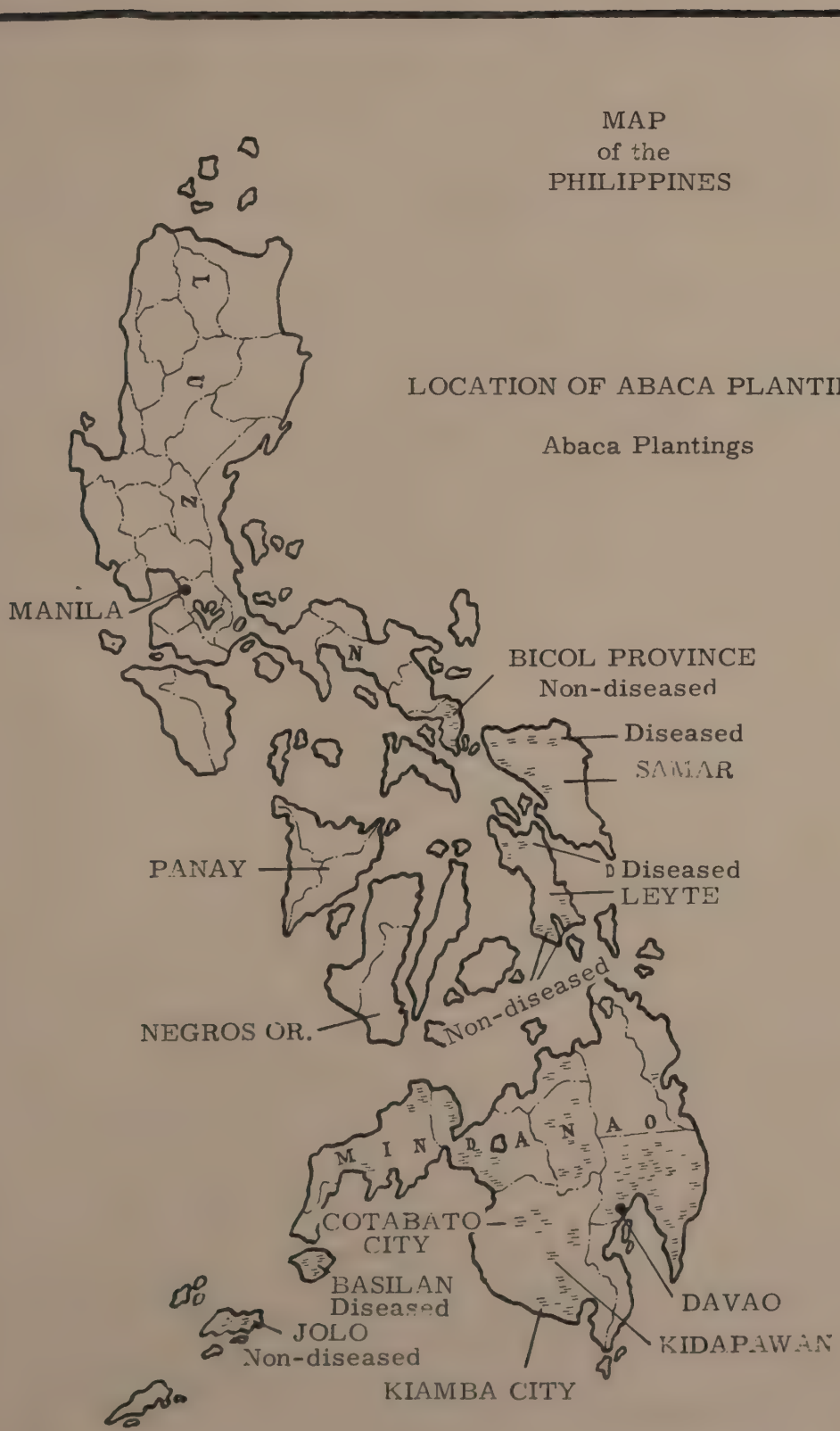
II. ECONOMIC IMPORTANCE

The epiphytotic of abaca mosaic in the Philippines has been one of the most destructive that has affected any large agricultural industry, being responsible for heavy losses of fiber and much capital investment, and, in the Province of Davao, the displacement of abaca culture from the highly fertile slopes of Mount Apo to remote regions. The losses which have occurred have been assessed by the Abaca Mosaic Control Headquarters, Davao City, and have been recorded by Reinking (24,25), who spent several years in the Philippines advising the Government on the control of the disease. There are about 184,000 hectares producing abaca in the Philippines and estimates prepared by the Bureau of Plant Industry in 1955 indicated that 88,000 hectares, or 47 percent are affected in varying degrees by abaca mosaic. Of the affected areas 75,000 hectares are in Mindanao and the remaining 13,000 hectares are shared between Samar and Northern Leyte. The disease-free areas of 96,000 hectares are comprised by the Bicol Region, the Southern part of Leyte, Negros Oriental Provinces, and the Island of Jolo. A further disturbing feature is that mosaic has invaded the most productive zones. Thus, in 1955, the estimated production of fiber from the 96,000 hectares of non-diseased abaca was only 289,000 bales compared with 497,000 bales from 88,000 hectares of abaca lightly to heavily infected with mosaic.

The deleterious effect produced by mosaic on an abaca plant or hill depends on the age at which infection takes place. If infected when young, plants soon become stunted and worthless, but if the disease does not show up until the hill is a year or two years old, worthwhile fiber can be produced before the hill loses its vigor; the amount depending upon plantation management and the fertility of the soil. Thus, it was of interest to the expert during his surveys in Mindanao to note mature plantations, which on critical examination showed evidence of the presence of mosaic in a high proportion of hills, freely producing apparently healthy stalks intermixed with occasional well-grown stalks showing mosaic symptoms in the upper leaves. There were reports, too, from reliable observers that it was common if known mosaic-infected mature hills were cut down for them to produce, in addition to some stunted mosaic suckers, apparently healthy stalks which would grow to maturity. Much of the abaca in Mindanao is thought to be in this condition of partial infection of hills. With good management many of the plantations will remain in production for years to come. There are many plantations that are more or less abandoned from which fiber is harvested only when it pays to strip. It is clear also that ther are many excellent plantations, both large and small, in which mosaic infection of hills is less than five percent.

Although great damage has been done by mosaic and a heavy toll of production is still being taken by it there is no justification for the assumption that the abaca industry will be wiped out by it. It is considered unlikely that production of fiber will fall much if at all, because of mosaic alone, say, during the next five years. During this time it should be possible to improve greatly control methods and cultural practices. While the disease has been a serious blow to the Philippines there is no question that it will always maintain its supremacy in abaca production.

The greatest handicap at present being imposed by mosaic on the abaca industry is the difficulty, because of mosaic, of establishing new plantings. It is a common experience for planters to lose 25 to 50 percent of hills to mosaic during the first year or so. This is because there is available to very few planters disease-free or even reasonably disease-free planting stock. Not only do heavy losses occur in the original planting but when refilling is done many of the replants also show mosaic before they mature.


MAP
of the
PHILIPPINES
LOCATION OF ABACA PLANTINGS
Abaca Plantings
MANILA
BICOL PROVINCE
Non-diseased
Diseased
SAMAR
PANAY
Diseased
LEYTE
NEGROS OR.
Non-diseased
MINDANAO
COTABATO
CITY
BASILAN
Diseased
JOLO
Non-diseased
KIAMBA CITY
DAVAO
KIDAPAWAN
After Reinking 1955
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III. SOURCES OF INFECTION

1. Importance of Primary Infection Arising from Seed-Pieces and The Significance of Latent Infection

In the early postwar years, many abaca plantations were planted with unselected seed-pieces which came from diseased plantations (22). This not only often led to complete failure of plantations but also served to disseminate the disease in new localities. There is general agreement that primary infection with mosaic was the cause of most of the early trouble and, in 1950, action was taken by the Bureau of Plant Industry, in the formation of the Abaca Mosaic Control Unit, with Headquarters in Davao City, to correct the position. Assistance was given to planters in the selection of disease-free planting stock from old plantations, which had survived the epiphytoti and were relatively free of the disease, and as a result of the activity of this unit, many excellent plantations were established. The success of such plantations as TADECO and DAPCO, a score of smaller plantations at Compostela and other good plantations in other districts, can be attributed largely to the care exercised in selecting the planting stock.

In spite of the official action taken, it nevertheless has come to be accepted by officers of the Abaca Mosaic Control Unit and of the Southern Mindanao Regional Station, as well as by planters, that if infection is carried by the planting stock such infection would display itself soon after a new planting appears above the ground.

As mentioned earlier, the chief handicap resulting from mosaic at present is in the establishment of new plantings because of the necessity to dig out and replant infected hills. Dr. Otto Reinking also stressed this difficulty in his 1955 Review of the Abaca Mosaic Control Program (24) stating that even when well isolated plantings were made with selected planting stock, severe infection resulted. In this connection, he refers to a nursery planting of 7,000 hills made by the Odell Plantation at Madaum in October, 1953, on an isolated island just off the mainland, in the absence of other abaca and corn. No record is available of the percentage of plants removed at the first roguing but at the second roguing, it was necessary to remove 33 percent.

Dr. Reinking refers to another planting of about two hectares (No. 2 nursery of the Davao Penal Colony) made in June 1954 in a clearing in heavy virgin forest. Planting material was selected from Lot 1 of the Penal Colony planting which was presumed to have had less than 5 percent disease. Eight percent of diseased hills were removed at the second roguing in December 1954, and it was stated that a similar amount was removed at the first roguing. Instances of the need for heavy roguing in other nurseries are also given, for example, 2,500 hills planted in May 1954, from which 25 percent were rogued at the first removal and 7 percent at the second; and 1,900 hills

planted May to June 1954, from which 9 percent was rogued at the first removal followed by 11 percent at the second. In the former planting, 6 percent of the replants had also to be removed at a subsequent roguing.

Roguing figures collected by the expert from nurseries and experiments indicated the same trend in the necessity for heavy roguing soon after planting, followed by a lesser amount, in spite of the best of care having been exercised in selecting the original planting material. The pattern of disease incidence is a well recognized one also among planters, who state that once their plantations are a year or eighteen months old, there is relatively little further loss from mosaic if management is good. Two instances will serve to illustrate the trend, both taken from experiments at the Southern Mindanao Regional Station, Bago Oshiro, Davao:

Manurial Experiment:

2167 Tangongon hills, planted November 19, 1955.

First roguing, 13 Feb., 1956 --- 14.3% of hills removed.

Second roguing, 3 Apr., 1956 --- 7.2% of hills removed.

Third roguing, 12 June, 1956 --- 2.4% of hills removed.

Fourth roguing, 8 Oct., 1956--- 7.6% of hills removed.

Catch Crop Experiment:

1,100 Tangongon hills planted April 13, 1956.

First roguing, 2 July, 1956 --- 19% of hills removed.

Second roguing, 21 Aug., 1956-- 8% of hills removed.

Third roguing, 19 Oct., 1956 --- 1.5% of hills removed.

The Catch Crop Experiment was examined in the field by the expert on several occasions with a view to determining whether mosaic was arising as a primary or seed-piece infection, or a secondary or field and vector-borne infection. The plots where catch crops had been grown, had been now placed under cover-crop or a routine of clean weeding. The abaca plants which had survived roguing were well grown and about eight months old. A random survey made by the expert on 28 November showed that mosaic was still appearing in some of the original hills and was found also in some of the replants. It was concluded that nearly all the infection was of the primary type and, as it was appearing in well advanced hills, it should rightly be called latent primary infection. There were symptom differences which enabled latent primary infections to be distinguished from secondary or field infections.

These will be described later, but it is of interest that in a count of 20 mosaic-infected hills found in the catch crop experiment plots on 28 November, only one showed symptoms which were judged to be the result of secondary or field infection.

The expert has formed the opinion that primary infection, and especially latent primary infection, because of its insidious or covert nature has been at the root of the difficulty in dealing with abaca mosaic in the Philippines. Lack of recognition of this factor has made it almost impossible to select disease-free planting stock and when it is accepted that infection may remain latent in some hills for 12 to 18 months or longer an explanation can be provided for many of the puzzling observations and experiences of the past. There has been a tendency to assume that after a year or so, the corm system of an abaca hill breaks up into a series of separate units. That this is a fallacy which must be corrected has been shown by studies already made on the corm system of abaca. It was concluded that many corms may remain linked for more than two years. The intricate corm system of a Tangongo hill is illustrated in Fig. 11 and shows what little chance there is of winning when gambling on whether one clump is disconnected from another or not.

2. Distinction between Symptoms Resulting from Primary and Secondary Infection

The symptoms of abaca mosaic have been described by several investigators (4,10,11,16,17), but none has endeavored to distinguish between the symptoms which follow first infection of a plant and those shown when the disease arises from an infected seed-piece. In several virus diseases, these symptoms can be well defined and it seems that it is also possible in the case of abaca mosaic.

An examination of the first symptoms of mosaic arising in abaca seedlings as a result of aphid transmission, and mechanical transfer using the carborundum method, was made at the Pest and Disease Research Section at the Southern Mindanao Regional Station. The first symptoms are substantially the same as those originally described by Ocfemia and Celino (21), and Celino (10). These are small, pale yellowish dots appearing about 8 to 10 days on the blade of the first leaf, or occasionally of the second one, unfurling after inoculation. The minute dots gradually elongate into streaks with the central dot remaining distinct for some time. In some seedlings, in addition to the yellow dots, yellowish diffused areas extending from the midrib in the direction of the margin of the leaf blade are also seen (Fig. 2). The leaf emerging after the first symptom leaf shows more advanced symptoms and in the case of Strain 2 of the virus, pronounced mottling. With this strain of the virus, which is the one commonly isolated from the field, there is usually a slight "shock" resulting in the second leaf which displays symptoms having a shortened leaf stalk (Fig. 3). Sometimes the blade of this leaf may also be reduced in size. The second leaf displaying

symptoms is usually the one which bears the typical mature symptom, but in occasional seedlings, it is seen on the tip of the first symptom leaf (Fig. 1).

The expert's examination of symptoms arising as a primary or latent primary infection from the seed-piece, was made in the Catch Crop Experiment block, planted with the Tangongon variety, at the Southern Mindanao Regional Station. The symptoms are illustrated in Fig. 4. If the disease appears as a latent primary infection in a plant which is several months old, first symptoms occur on the underside of the midrib and leaf stalk of an otherwise normal fully expanded leaf (Fig. 4). It is usually first detected as dark brown to black areas or elongated streaks, but it is probable that before darkening the discolored areas are pale yellow or whitish. At this stage, no sign of abnormality can be seen on either the upper or lower side of the blade of the first symptom leaf. The next leaf is usually entirely without any marking either on the undersurface of the midrib or the upper or lower surface of the blade, but occasionally there is one or two yellowish or whitish bleached areas on the base of the leaf stalk. The following leaf shows yellowish or bleached areas (which may darken) on the base of the leaf stalk and extending up and along the underside of the midrib. The blade of this leaf for the first time shows symptoms. These may be yellow dots and spindle-shaped streaks, or a diffused yellowsish area extending out from darkened areas on the underside of the midrib, or both. The following leaf may have symptoms similar to the last or show the mature-type mosaic pattern.

This extraordinary sequence of symptoms is quite distinct from those resulting from artificial inoculation, where the first symptoms are on the blade, and is distinct also from those shown by plants in the field, which were judged by the expert to have succumbed to field or secondary infection. In such cases, the first symptoms appear on a leaf blade as a few yellow dots and spindle-shaped streaks, as in the case of artificial inoculation, and the following leaf shows the mature-type of mosaic pattern. The onset of the disease also usually causes a slight "shock" leading to a shortening of the stalk of the leaf.

The reason for the difference between primary and secondary symptoms is not known but it is thought possible that the virus which has been lying latent in the starchy corm tissue moves first up the leaf sheath rather than directly to the growing point of the plant. Having reached the midrib of a leaf, it is conducted down, with the movement of sugars, to the growing point, which it does not, however, reach in time to invade the next leaf which is emerging. This might account for the lack of symptoms in this leaf. The virus from then on seems to invade all subsequent leaves from its position in the growing point.

Recognition of latent primary infection enables an explanation to be given to the rather mild type of onset of the disease seen in plants. Fig. 5 illustrates its onset in a plant 8 months old. Fig. 7 shows the apex of a plant 18 months old in which the disease had only recently appeared. Other cases were seen where symptoms appeared first in the inflorescen

Fig. 6 illustrates a hill 13 months old in which the disease displayed its presence simultaneously in four suckers at 12 months, while the two main plants in the hill remained healthy.

The symptons described above are worthy of much closer study than the expert was able to give them as they are of fundamental importance in deciding whether infection stems from the seed-piece or the field. The decision is a critical one in relation to seed banks planted on a hill-row system. One of the first steps in making this study will be the artificial inoculation in the field of healthy plants of known history and of different ages, say from two to twelve months.

3. Degree of Importance of Secondary or Field Inspection

It was impossible to decide fully this point during the expert's brief investigation but a strong impression was obtained that under conditions of good plantation management, field spread of abaca mosaic may be small indeed. It is envisaged that if disease-free planting stock were available, grass weeds were kept at a minimum during the first 18 months or so by heavy cover cropping, and maize plantings were not too closely adjacent, losses from secondary or field infection should not exceed a few percent of hills, before a plantation is brought into fiber production. Subsequently, if complete removal of the few diseased hills which might have occurred is carried out, and a closed canopy of foliage is maintained by avoiding over-stripping, grass weed growth will be of a minor nature and losses from mosaic accordingly small.

There is evidence in support of this viewpoint when one considers the histories of a number of successful plantations which were established from 1950 onward with planting stock selected with the aid of officers of the Abaca Mosaic Control Unit, Davao City. One of the most striking of these is the TADECO Plantation owned by Mr. A. Floirendo at Tagum, Davao, which is probably as successful a plantation as ever has been established in the Philippines. In this planting, 742,000 rootstocks, selected by the Bureau of Plant Industry from 1950 to 1953 were used (24) and management, weed control and disease control practices have been excellent.

There is published evidence, too, which supports the view that secondary or field infection is not as great as some have thought. As shown in Table 1, extracted in full from a 1956 publication of Castillo, Agati, and Otanes (8), in a series of ten plantations, varying in ages from 5 months to 4 years, from which diseased hills were removed completely, subsequent infection was of a relatively low order compared with the initial infection. Fig. 12 is also an extract of a chart from the same publication and records the initial and subsequent infection after 290 days in a three-

year old plantation. It is considered, in view of present knowledge regarding latent primary infection that not all of the 13 hills which subsequently showed mosaic should be regarded as secondary infections. Almost certainly, six infections which occurred near the margin of the planting could be in this category but the origin of the others is doubtful.

Table 1 - Spread of the Abaca Mosaic in Plantations where Diseased Hills were Eradicated and Replanted with Healthy Seedlings*

Name of Planter and Locality	No. of Hills Studied	Age of Plants	Date Treated	Initial Infection		Date Re-treated	Subsequent Infection		Monthly Infection	
				Hills infected	Percent		Hills infected	Percent	Hills infected	Percent
Serafin Chicote, Gnambog, Pantukan, Davao Province	1,046	5 mo.	11. 9.51	152	14.53	8.3.52	11	1.05	1.83	0.17
Pascual Beject, Kidapawan, Cotabato	1.092	6 mo	7. 4.51	358	32,80	27.2.52	64	5.86	5.81	0.53
Roberto Lapasa, Lasang Davao City	1,190	6 mo.	28.12.50	138	11.63	8.2.52	53	4.45	3.92	0.32
Eustaquio Tapion, Bobud, Davao City	1.152	1 yr.	10. 7.51	116	10.07	12.2.52	8	0.69	1.14	0.09
Gesmundo Torralba, Magnaga, Pantukan Davao Province	1.000	1 yr.	28. 6.51	132	13.20	7.3.52	41	4.10	4.82	0.48
Crisologo Estuqui, Southern Davao, Panabo, Davao Pro.	1,120	3 yrs.	29.10.51	50	4.46	11.2.51	28	2.50	8.00	0.71
Ramon Cabaluna, Little Pahay, Panabo, Davao Province	1,120	3 yrs.	16. 6.51	176	15.71	8.2.51	36	3.22	4.50	0.40
Julian Cosa, Pindasan, Pantukan, Davao Province	998	3 yrs.	26. 5.51	58	5.81	7.3.52	6	0.60	0.63	0.06
Elias Dacudao, Lasang Davao City	1,431	3 yrs.	29. 4.51	83	5.80	8.2.52	13	0.91	1.36	0.09
Juanito Adolfo, Dumoy Davao City	1,238	4 yrs.	5. 5.51	465	37.60	13.3.52	66	5.35	6.96	0.56
Total	11,387	17 yrs.		1,728	151, 61		326	28.73	38.97	3.41
Average	1,137	1.7 yrs.		173	15.16		33	2.87	4	0.34

* Taken from the records of the Mosaic Control Headquartes. Re-treatment was done after 257 days.

4. Significance of Corn Plantings in the Spread of Mosaic

There is a great deal of evidence of a close association between a high rate of spread of mosaic and the practice, which was very common during the postwar years, of interplanting maize in young abaca plantations. The aim, of course, of the small planters was to grow a food crop during the rather long and costly period of bringing an abaca plantation into production. Usually, two or three plantings of maize were made in the same plantation. In the postwar years, there was a big influx of settlers to Davao and Cotabato provinces, many of whom were people who preferred to eat maize rather than rice. It is reported that many of them had also little knowledge of abaca production and paid little if any attention to the selection of mosaic-free planting stock. Under these conditions, there was general failure of plantations, many being reported 100 percent infected with mosaic before any fiber was harvested. The heavy losses which occurred have been well recorded by Reinking (24,25). The Abaca Mosaic Control Unit made a study of the rate of spread of mosaic in a series of plantations in Kidapawan and Davao City which were interplanted with maize (8). The plantations were planted with selected planting stock and diseased plants were placed at random to serve as sources of inoculum. The average initial infection in the eight plantations studied was 30.21 percent. After one year or about three plantings of maize, the average infection had increased to 80.17 percent.

It can be accepted that interplanting maize is a hazard to abaca, if there is any initial infection in the plantation. The risk maize introduces is twofold. It is the normal and highly favored host plant of Aphis maidis, one of the vectors of abaca mosaic, and it also can harbor the virus, apparently in high concentration, if it becomes infected. Maize is an annual, and observations made by the expert in Mindanao during November, indicate that when maize is grown by itself, it is relatively rarely affected with any form of mosaic disease. It is considered therefore, that it is the combination of maize and abaca in close contact that creates the problem.

The evidence is not so sound that maize plantings in the vicinity of abaca plantations, say 100 meters distant, are a menace and will greatly increase the rate of spread of abaca mosaic. The danger of nearby maize plantings has been heavily stressed by Reinking (24). It is, however, of considerable practical importance to define the degree of danger in regard to distance, and relative to heavy weed growth of grasses which, too, are subject to heavy infestations of the vectors. Why should all the emphasis be placed on maize? The fact should be faced that many of the inhabitants of Mindanao are now maize-eating people who wish to grow abaca. It might be possible to work out a system that maintains control of the disease yet suits the people.

Good biological support could be given to any legislation that might require that maize not be interplanted with abaca, and also within a short specified distance from it, but in view of the wide range of grasses which can harbor the virus and build up high populations of the vectors, care should be taken with legislation which excludes maize planting from vast areas of land. The expert thus views with concern the Zonification

Act, Republic Act No. 1176. This Act will be extremely difficult to implement in view of the squatter problems, and it is also doubtful that it will serve the purpose for which it was designed. There will also be much local opposition in buffer zones, where farmers have holdings on which they wish to carry out mixed farming.

Already, it has been demonstrated that isolation from maize does not ensure that the planter will obtain a mosaic-free plantation. A good illustration is available from the Insecticide Experiment designed by Dr. G. Mathysee, visiting professor of the College of Agriculture, Los Baños, and conducted at the Odell Plantation, Madaum, Tagum, Davao Province. This experiment of six hectares was planted in a clearing in virgin forest, well removed from any maize in September, 1955. Details of infection up to 6 July, 1956 were kindly given to the expert by Mr. E.H. Houser of the Odell Plantation (see Table 2). Complete treatment (uprooting) was carried out out when infected hills were encountered. It will be seen that mosaic ranged from 10.5 to 55.8 percent in the 18 plots in this experiment, being considerably less in the plots C-1, C-2 and C-3 which were interplanted with Controsema cover crop. It is difficult to estimate how much of the infection came as primary infection from the planting stock but it was probably less than 5 percent judging by the general condition of health of the Odell Plantation. It seems highly probable that a very severe outbreak of field or secondary infection occurred. Inspection of the experiment by the expert on 3 November, 1956 showed that grass weeds were common in and around the plantation, particularly along ditches and headlands. Almost every plant of Paspalum conjugatum examined was affected with mosaic. Thus, it seems that some abaca mosaic virus was introduced into this isolated clearing (well removed from maize plantings) in primary infected planting stock, grass weeds became established, aphid vectors migrated in and colonized the grasses, most probably directly infecting them with mosaic, and a set of conditions was provided for a rather unusual outbreak of field infection. The point it is desired to stress, however, is that this serious outbreak of mosaic occurred in isolation from maize plantings.

While maize close to abaca is regarded by the expert as a potential danger which should always be avoided if possible, it is worth recording that one plantation visited by the expert at Tagluno, Davao City, was successful in spite of being surrounded on all sides by maize, adjacent and for many hectares around. This plantation of about one hectare, owned by Mr. Pastor Hernando, was about three years old. It had been planted with variety Tangongon lawaan selected from a nearby old plantation. When young, it had been interplanted with maize, followed by rice. The manager (Mr. Herman Aguilar) stated that in the first two years, mosaic infection was no higher than "about one percent". Inspection of the plantation indicated that infection was now about 4 or 5 percent if recently replanted hills were taken into consideration. The plantation was almost completely free of grass weeds and it is considered that clean weeding, probably from the earliest planting and relatively disease-free planting stock enabled this plantation to be brought into production in spite of maize plantings all around. Another thought also occurred to the expert and raised the question. Is the abaca variety Tangongon lawaan more resistant to mosaic under field conditions than ordinary Tangongon?

Table 2 - Insecticide Experiment at Odell Plantation 1955 - 1956

Treatment: A Systox dipped seed and spraying of abaca.

B Systox spraying of abaca and weeds.

C Centrosema cover crop.

D Control.

E Systox spraying of abaca.

F Benzene hexachloride spraying of abaca and weeds.

Area of plots: 1/3 hectare. 50 meters x 60 2/3 meters.

Three replications of each treatment in random block design.

Planted September, 1955.

Figures indicate percentage of mosaic infection up to 6 July 1956

B-3 38.1	D-3 19.5	F-3 13.5	E-3 20.6	A-3 19.4	C-3 12.9
C-2 10.5	E-2 21.4	B-2 14.4	A-2 33.1	D-2 23.9	F-2 19.0
A-1 45.7	F-1 19.6	E-1 20.2	C-1 12.8	B-1 32.7	D-1 55.8

Layout and center ditches make eastern and western boundaries between plots.

Prominent stakes were placed to indicate north/south boundaries between blocks. No plants were placed on the boundary line between blocks.

(Above data supplied by Mr. E.H. Houser, Odell Plantation, Madaum).

IV. MEASURES FOR CONTROLLING ABACA MOSAIC

1. Methods Worthy of Trial in Obtaining Disease-free Planting Stock

An endeavor has been made to attract attention to the fundamental importance of disease-free planting material and the danger of grass weeds, both as a source of the abaca mosaic virus and of its aphid vectors. Unfortunately, disease-free or nearly disease-free planting stock is not readily available except perhaps to a few planters who have practised complete treatment of infected hills for a number of years.

It might be possible if thorough surveys are made still to obtain disease-free stock from old, isolated, plantations in Mindanao. There are reports, for instance, that some old plantations in Bukidnon are still free of the disease. Failing this, consideration could be given to importing disease-free stock from the island of Jolo or from Southern Leyte, where it is understood varieties closely related to Tangongon occur.

Because of the danger of grass weeds, any disease-free stock obtained will need special management, such as planting in an area cover-cropped with Pueraria to choke out grasses. It would be advisable, too, to protect the abaca plants from ant infestation by the use of a dieldrin ground-spray on the ring-weeded area surrounding each hills. Reference will be made to this last suggestion later in this report.

If it is found that disease-free stock cannot be procured by selection or importation, it is considered possible to develop it from the best existing stock by thorough roguing, in seed banks or stud plots. It is proposed that the principles used throughout the world in obtaining and maintaining mosaic and leafroll disease-free potato planting stock be adapted to the abaca industry. It is thought that from now on, the Philippines must "learn to live" with abaca mosaic as is done with many other crop diseases in other countries. The system used usually involves the maintenance of government-sponsored seed certification schemes. Sometimes, the seed is grown at government stations, or, the seed is grown by farmers and the Government provides inspection and instructional services to assist the farmers, who if they co-operate, may sell the seed as "approved" seed or under some similar name.

In developing disease-free planting stock by roguing in seed banks or stud plots, again first attention should be given to control of grass weeds. There have been experiments on weed control in progress f r a number of years at the Southern Mindanao Regional Station and it has been demonstrated that cover cropping with the leguminous plant Pueraria javanica is highly effective in choking out grass and other weeds. Examination of the root system of Pueraria by the expert at a number of locations in Mindanao showed that it was always abundantly nodulated with a highly effective strain of Rhizobium (judged by large nodules with pink

interior) and thus in addition to choking weeds, Pueraria has a special value in fixing atmospheric nitrogen. Examinations which were made of the root systems of Centrosema and Calopogonium at a number of places did not reveal effective nodulation (the nodules when present were small), scattered over the fibrous roots and had greenish or watery interiors. Growth of these cover crops was also usually much inferior to Pueraria. It is, therefore, considered that a few months before a seed bank is planted, a crop of Pueraria should be planted to choke the grass weeds and when sufficient cover is obtained, the area be lined, ring-weeded, and planted.

The method of planting should follow the hill-row system used in the control of potato virus diseases. Complete hills of selected abaca should be dug, the seed-pieces placed together in a basket or a sack, and planted one after the other in rows with a stake clearly marking the division between each hill-row.

The roguing of hill-row planted plots should be done at frequent intervals after the plants appear above ground by persons who are fully familiar with the symptoms of primary or secondary infection. If a primary infected plant appears in a hill-row, the whole hill-row should be removed and the sites replanted on a hill-row basis from another selected hill. If the rogueer is certain the infection is clearly of the secondary type, the single hill only need be removed but when there is doubt, it should be treated as a primary infection, or, the hill-row should be kept under close observation for the next few months. The advantage of hill-row planting will be that if any infected hill is included by accident, or because of latent infection, in a seed bank, the disease is likely to reveal its presence within the first two or three months after the plants appear above the ground in one or other of the members of the hill-row.

No quarter must be given in seed-banks to mosaic hills, even when they are twelve or more months old. They must be completely removed. It will be advisable, too, to allow a seed bank to reach an age of about eighteen months or two years old depending on rate of growth before the alternate hills are removed to make a new planting. It is considered that in the case of a government seed-bank, planting stock, before certification, should have gone at least twice through rogued hill-row planted seed banks, under Pueraria cover crop.

The production of disease-free planting stock for a vast industry, such as abaca, would be a large undertaking and it is considered that encouragement should be given to a number (say 10 to 20) of selected farmers in each different region to become commercial seed producers. It is thought that this might be done by close co-operation between the abaca mosaic disease inspectors in the different districts with selected farmers whom they would assist in obtaining the best available planting stock, Pueraria seed for cover cropping, and instruct in the technique of hill-row planting and roguing. A training course for inspectors would be a preliminary necessity, to explain the seed bank plan, point out the differences between primary and secondary infection, problem of latent infection,

and the value of Pueraria in choking grass weeds, reducing weeding costs and fixing atmospheric nitrogen. Regional planter-owned seed-banks should be closely supervised by the district inspectors and records kept of disease incidence, maintenance, etc. If in the opinion of the officer-in-charge of the Abaca Mosaic Control Unit, Davao City, these records reveal a general freedom of the seed-bank from mosaic, the grower could be issued with a permit to sell a specified number of "approved" seed-pieces. It is presumed that such seed-pieces would sell at a premium over ordinary seed.

It is considered also that a small trial should be made at the Southern Mindanao Regional Station of raising disease-free planting stock by rigid selection from true seed -- say of a specially made Tangongon x Tangongon cross, and field-run of Tangongon seed obtained from a pure stand of Tangongong well removed from other abaca varieties. Discussions, the expert had with officers of the Fiber Section of the Bureau of Plant Industry indicated doubt that high fiber-yielding stock could be obtained by this method, but it was admitted that the method had never been submitted to trial to asses its feasibility. The expert envisages that there would be selection done towards the Tangongon type in the seedbed, nursery rows, and after planting out. It is not suggested that true seed be distributed to farmers. The necessary selection of seedling material should be done at a Government Station and with the greatest care being taken to avoid infection from weeds.

2. Complete or Partial Treatment of Diseased Hills

There is no question that in a seed-piece bank, a young plantation, or and old or mature plantation with a low percentage of infection of mosaic, complete treatment of hills should be the only method tolerated. If this is not done, the seed-piece bank will be of little value, a young plantation will be unlikely to succeed, and a mature plantation will have its life shortened or its market value lowered.

With mature plantations, a question of economics arises because mosaic-affected hills have a fiber value not only in relation to mature stalks that are ready to be tumbled, but also to those that will produce fiber later before the infected hills become worthless. There is also the risk if the canopy is broken by the destruction of a group of infected hills, that grass weeds will appear in the gap and become infected with mosaic; such infected grasses present a far worse source of inoculum than the infected hills that have been removed. This is because of the closer affinity of the vector aphids for grass weeds than for abaca.

It is difficult to decide at what degree of infection of a mature plantation complete treatment of diseased hills should be abandoned in favor of partial treatment or the so-called "partial-complete" method. On present knowledge, the decision should be an arbitrary one. It is the expert's opinion that when a plantation has above 5 percent infection, it is likely to prove uneconomic to practise complete treatment, and the gaps created in the canopy thereby will contribute more to shorten the life of a plantation than if the infected hills were left in situ.

Reverting to the methods used in the potato industry for controlling virus diseases, there seems no reason why an abaca planter should not classify part of his plantation as a fiber-production area and a small part as a stud plot or seed-piece bank. If this is done, nothing but complete treatment should be given in the stud plot, or, throughout his plantation if it contains a low percentage of mosaic. If the main portion of his plantation contains more than 5 percent infection, partial treatment, with destruction of the hills only when they become weak, would seem the best proposition. All replanting, however, should be done with seed-pieces obtained from a stud plot or seed bank that always has received complete treatment.

3. Prospects of Controlling Aphid Vectors

Aphids, other than Pentalonia nigronervosa, were observed only occasionally, and generally in small numbers only, by the expert on abaca during his surveys in Mindanao. There was always an abundance, however, to be found on nearby weeds and grasses. In one small seedling-abaca nursery bed a heavy infestation of Aphis gossypii was noticed on a few plants.

Attention has been given to estimating aphid vector populations on abaca and weed hosts by Castillo, Agati, and Otanes (8) at different periods of the year. Their results indicate that both Aphis maidis and Aphis gossypii populations are subject to wide fluctuations throughout the year but they are more abundant during wet than dry months. They record a close association between aphids and the fire ant, Solenopsis germinata var. rufa, and the black ant, Dolichoderus bituberculatus. These ants were found very active, tending and moving aphids from one plant to another in the plantation, particularly in wet weather, when they carried and deposited aphids on the undersurface of the leaves.

The direct control of aphid vectors by the use of chemicals has been tried and is, in fact, used commercially in one plantation -- TADECO. The results of one experiment indicate that control of aphids by spraying had a beneficial effect in reducing the rate of spread of mosaic but as there were 16 spray applications, costs would be prohibitive. (8).

It is considered that the best approach in controlling aphid vectors would be an indirect one, aimed at controlling the weeds on which they normally feed. This could be achieved by heavy cover-cropping the are with Pueraria. When this is done, weeds are choked out not only within plantations but also in headlands and along drainage channels. Grass weeds will continue to grow, however, in the ring-weeded area around each hill. The suggestion is made that control of ants in these areas, or their activity in carrying aphids, might also be worthy of trial, as a method at least applicable to seed-piece banks. An experiment using dieldrin as a low and high volume spray and applied mixed with soil was begun at the Southern Mindanao Regional Station by the expert on 6 November 1956. The experiment was laid down over a hectare and involved ten

replications of the treatments. It was superimposed on the former catch crop experiment, but owing to the occurrence of latent-primary infection in this block, recording of the outcome of the treatments will need to be done with great care.

4. Abaca Mosaic Control Campaign

The Abaca Mosaic Control Campaign was commenced in 1950 with the aid of a special Government fund of 500,000.00 pesos and is still in operation from its Headquarters at Davao City, with an Executive Officer stationed in Manila. During the first few years a large force of inspectors and field laborers (710 personnel at its peak) were employed on the selection of disease-free planting material and the detection and treatment of mosaic-diseased plants. The numbers employed declined steeply during 1953 and 1954. During 1955/56 the campaign personnel ranged from 140 to 160 a month. A total of 7,031 hectares belonging to 1,802 farmers were covered during the year, 430,560 diseased hills were treated and replanted, and 940,051 diseased clumps were removed from older plantations (14).

At the present time, a total of 45 are employed, made up of two executive officers, 17 inspectors and 26 other personnel (1). The manner of operation of the campaign has also necessarily changed to advising and assisting farmers who are prepared to do complete treatment in the detection of mosaic hills and encouraging them to establish seed-piece banks.

The campaign has been a costly one but it served its purpose in saving the industry from being wiped out by mosaic. It has been responsible for the success in the establishment of many large and small plantations which still are relatively free of mosaic. It also built up a team of competent and enthusiastic inspectors who know their districts in detail and are still carrying on valuable work. The writer is convinced that this campaign must continue with provision made for its personnel and expenses in the annual budget, so that there will be fewer interruptions to its operations. The impact of mosaic on the abaca industry has weakened and a state of equilibrium has been established; losses from mosaic being balanced by continued replanting or the planting of new areas. It is in connection with replanting and the establishment of new plantings that the inspectorate of the Abaca Mosaic Control Headquarters can yet play its finest part in the rehabilitation of the industry. The direction in which its efforts should now trend is the encouragement of more planter-owned seed banks, planted in a cover-crop of Pueraria and in which mosaic hills receive complete treatment. The inspectorate can also facilitate the location and procurement of the best available planting stock for planters and particularly can assist in roguing on a hill-row basis, which requires a knowledge of the symptoms of primary and secondary infection.

In view of the reduced personnel now employed on the control of abaca mosaic, use might be made of a faster method of destroying diseased

and unwanted hills than that developed in 1951 by Castillo and Agati (6). This method is illustrated in Fig. 13 and also uses weedicides, but the chemical is injected under pressure through a hollow steel needle into the growing point of each plant in the hill. This method has been used with success in bunchy-top affected areas, in abaca plantations in North Borneo.

5. Breeding Mosaic-resistant Varieties

Time did not permit a full examination of this program which has been in progress for some years at the Southern Mindanao Regional Station and at Los Baños. While breeding for resistance is of necessity a long-term project, nevertheless, with a field crop such as abaca and the contender, a multivector virus which has so many weed reservoirs, the prize is well worth seeking no matter what effort it takes. There is, too, encouragement in the Pacol -- Musa balbisiana, a fiber plant more like a huge banana than an abaca - has high resistance to mosaic, and can also be crossed with it. Crosses have also been made between Musa lolodensis and the abaca variety Tangongon and it is probable as the work proceeds other Musa species will be considered. Details of progress to date have been recorded by Cruz (14).

Should further research on the nature of the virus confirm that the abaca mosaic virus belongs in the sugar cane maize mosaic group of viruses, this would be further encouragement for the abaca breeder to sustain his efforts. The sugar cane mosaic problem of all sugar cane growing countries has, under the influence of resistant varieties, commencing with the P.O.J. canes, yielded to the skill of the plant breeder.

V. SUMMARY AND RECOMMENDATIONS

1. Abaca mosaic has been a highly destructive disease and is still taking a heavy toll of production, but it appears to have reached an equilibrium with the industry losses being balanced by replanting and the development of new plantations. In the expert's opinion, there is no justification for the assumption that the industry will ever be wiped out by mosaic. In spite of the losses being caused, the disease is nevertheless well under control.

There is, however, urgent need for improvements to be instituted in methods of control. The greatest handicap at present imposed on the industry by mosaic is the difficulty it causes in establishing new plantings.

2. The disease is considered to be caused not by cucumber mosaic virus, as hitherto thought, but by a mixture of strains of a virus of the grass-mosaic group or a complex of strains belonging to this group and a similar undetermined virus.

It is recommended that research in progress in the Bureau of Plant Industry and at the College of Agriculture, Los Baños be continued in an endeavor to identify the strains of virus that cause abaca mosaic. One direction in which this work might proceed is the testing of as many strains as possible of sugar cane, corn and grass mosaics for their effects on abaca, both singly and in different combinations.

3. All observations of the expert point to grass weeds (oulapé) Paspalum conjugatum, crab grass Digitaria sanguinalis and Panicum colonum and possibly others) being the natural sources of the virus, that is, the disease is primarily one of grasses but under certain conditions spreads to abaca. In this concept, maize may be regarded as a tall grass; when interplanted with abaca, maize becomes equivalent to a severe infestation of a grass weed. It is considered that as the vector aphids do not ordinarily colonize on abaca the main direction of spread of the disease is from grasses to abaca. For the same reason, abaca is a receptor but only a relatively poor donor of the virus. Hitherto, the emphasis has been placed on infected abaca as the prime source of the virus and many millions of infected hills have been destroyed in an endeavor to prevent dissemination of the disease.

It is recommended that further detailed studies be made on grasses and other monocotyledons as sources of the virus and their liability to seasonal infestations of vector aphids. Further studies should also be made on the leafhopper, Proutista moesta, and its ability to act as a vector of the virus.

4. Once an abaca plant becomes infected, the virus enters the intricate corm system and rapidly or slowly, partially or completely, moves throughout the system. If the movement of the virus is rapid, symptoms of mosaic soon show up throughout the hill, but if the movement of the virus is retarded, only part of the hill gives evidence of infection, and there is risk of apparently healthy, though infected, planting material being chosen. The use of such infected planting material in the past has undoubtedly been the cause of high incidence in new plantings and the consequent failure of many plantations. In other words, a great deal of the losses have been caused by primary or seed-piece infection rather than by secondary or field infection.

5. Surveys made by the expert indicate that in addition to primary infection, which has been generally recognized, latent primary infection also occurs. The term 'latent' is applied because infection arising from the seed-piece may not in some cases display itself by mosaic symptoms until hills are several to many months old; sometimes not until the inflorescence emerges. The symptoms of latent primary infection are described and compared with those of secondary infection.

6. The relative importance of primary and secondary infection is discussed. While under certain conditions field infection can be serious, in well managed plantations it occurs much less frequently than has been thought.

7. There is very clear evidence that interplanting of maize with abaca is a dangerous practice. It is not established, however, that maize 100 meters or so distant from abaca is a menace and would greatly increase the rate of spread of mosaic. It is of considerable practical importance to define the degree of danger maize creates not only in regard to distance but also relative to heavy weed growth of grasses, which, too, are subject to heavy infestations of the aphid vectors. The facts must be faced that many of the inhabitants of Mindanao are now maize-eating people who wish also to grow abaca.

Good biological evidence could be given to support any legislation designed to prevent interplanting of maize with abaca or within a short specified distance from it, but in view of the wide range of grasses that can also harbor the virus and build up high populations of the vectors, care should be taken with legislation that excludes maize from vast areas of land. The expert thus views with concern the Zonification Act, Republic Act No. 1176, and recommends that much further technical discussion should take place before its full implementation. It is further recommended that as soon as disease-free planting stock becomes available, well designed experiments be laid down to determine at what distance maize plantings cease to be a hazard to abaca.

8. One of the main problems of the abaca industry is that disease-free, or nearly disease-free, planting stock is not readily available except to a few planters who have practised complete treatment of infected hills for a number of years. Methods worthy of trial in obtaining disease-free stock are outlined in this report. These involve adaption, to the abaca industry, of the methods found effective in other countries in controlling potato virus diseases. The adapted methods are selection of stock from disease-free areas, hill-row planting and roguing, use of cover-cropping to smother and choke out grass weeds, Government-sponsored seed certification scheme, and regional farmer-owned stud plots or seed-piece banks. Experiments conducted at the Southern Mindanao Regional Station have demonstrated the great value of the cover crop, Pueraria, in control of grass weeds, and it is considered likely that the wide use of this crop will play an important role in the rehabilitation of the industry. Pueraria will make a special contribution because of its effective modulation in fixing atmospheric nitrogen and, also, in reducing the costs of weeding.

It is recommended that a complete change be made in the function and operation of the Southern Mindanao Regional Station. The production and distribution of disease-free abaca planting stock, should be declared the primary function of the Station, and it should be made an offence, punishable by dismissal, for any person in the Station to carry out partial treatment of infected hills in any future planting. Despite the large amount of money that has been spent over the years at this Station, there is not yet available from it any disease-free planting stock. This deficiency can be attributed largely to the fact that this Station has practised partial, rather than complete, treatment of infected hills when they become large. While the Station has carried out some very valuable experiments on cover crops, shading etc., other experiments, for example, the Fertilizer Experiment, have been of limited value because of the need of constant replanting. Until disease-free stock is available it would be wise to curtail or abandon further experiments and devote all energies and finances to deriving disease-free planting material. It is also recommended that in the interest of the future of the abaca industry an early solution be sought for the squatter problem at the Station.

9. The question of complete or partial treatment of diseased hills is discussed. There is no question that in a seed-piece bank, a young plantation or a mature plantation with a low mosaic incidence, complete treatment of hills should be the only method tolerated. In mature plantations with a high disease incidence, on the other hand, it is uneconomical to practise complete treatment, no matter how effective this would be; there is a point at which complete treatment is not a good proposition. A farmer who practises partial treatment should, however, convert a portion of his plantation to a seed-piece bank in which only complete treatment is allowed.

10. The prospects of controlling the aphid vectors have been examined and it is concluded that only indirect methods, for example, smothering the grass weeds that serve as reservoirs of the virus and build up vector populations, are feasible. Because grass weeds will grow in the ring-weeded areas around hills in young plantings, and a close association seems to exist between ants and the aphid vectors, it is considered possible that control of ants by ground-spraying with dieldrin would prove beneficial in seed banks. It is recommended that research be continued to determine whether such ground spraying would be both effective and profitable.

11. The Abaca Mosaic Control Campaign, which has operated since 1950, has been instrumental in saving the industry from being wiped out by mosaic. The expert is convinced that this campaign must continue, with modifications, and that it will yet play its finest part in rehabilitating the industry. It is considered that its activities should be concentrated in building up regional farmer-owned seed-piece banks.

It is recommended that permanent provision be made in the annual budget for the conduct of this campaign so that there will be fewer interruptions to its operations than have occurred in the past.

It is also recommended that, henceforth, government assistance be given to planters only in connection with the procurement of planting stock and the building up and roguing of seed-piece banks, and that no government aid be given in the fiber-production portions of any plantations.

12. The program of breeding for mosaic disease resistance is making progress and it is recommended that it be continued with the inclusion of other species of Musa as possible sources of resistance.

APPENDIX 1

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APPENDIX 2

BUNCHY TOP OF ABACA AT GOVERNMENT EXPERIMENT STATIONS

During field surveys at the Guinobatan Experiment Station on 20-21 November, 1956, the expert was unable to find any sign of abaca mosaic, although the site was inspected where several hills affected with mosaic in 1952 had been eradicated. From discussions the expert had with Mr. Domingo Protacio, plant pathologist at the Station, who is familiar with mosaic, he is convinced that abaca mosaic did occur at Guinobatan as reported by Professor Ocfemia (Phil. Agriculturist 38: 84-87, 1953).

During these surveys the expert encountered a form of the bunchy top disease in the Itom and other varieties of abaca. This form of the disease is the chronic, partially-recovered type which the expert studied in the ex-Japanese abaca estates in North Borneo in 1946 and 1950*. The disease did not appear to be doing much obvious damage to the Itom variety, but in some other varieties it was causing some hills to be very weak in growth. The disease was noticed in the following varieties in addition to Itom: Inagutang, Borogtonon, Degoma, Inisarog, Bulao and Ugarom.

The existence of this disease on a government station is considered most undesirable. Its presence had previously been undetected, although it was reported that the more easily recognized acute form of bunchy top occasionally occurred in a block of hybrid abaca, which is across the road from a chronically-infected Itom block. In North Borneo, the chronic form of bunchy top has been responsible for heavy losses, apparently due to its reversion to the rapidly spreading acute form, with which heart rot is associated. It is recommended that as opportunities occur an investigation be made of the full extent of the bunchy top infection at the Guinobatan station.

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* Magee, C.J. 1946. Report to the British Colonial Office on the ex-Japanese Hemp Estates in North Borneo.

Magee, C.J. 1950. Report to the Colonial Development Corp., Singapore, on the Health Status of Hemp Estates in North Borneo.

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At the Southern Mindanao Regional Station, Bago Oshira, Davao City, bunchy top was also encountered in the Tangongon variety. Its presence at this station was previously known since hills are often found affected with bunchy top in abaca blocks not far from the research laboratories. The expert was informed by Mr. P.C. Pacambaba, fiber technologist, that these outbreaks are thought to be related to the importation, about 1950, of rootstocks of a hybrid variety from Luzon, which was reported to be resistant to bunchy top. These rootstocks were planted in a plot near the research laboratories, and in 1953, there was a severe outbreak of acute bunchy top in this plot, causing it to be eradicated.

The bunchy top affected Tangongon plants were observed by the expert in the "Systemic Insecticide Experiment" block and also in another block over the road from the "Catch Crop Experiment." It is recommended that every effort be made to eradicate bunchy top from the Southern Mindanao Regional Station, since the disease is potentially dangerous and could seriously upset any plans to raise mosaic-free planting stock at this station.

ILLUSTRATIONS

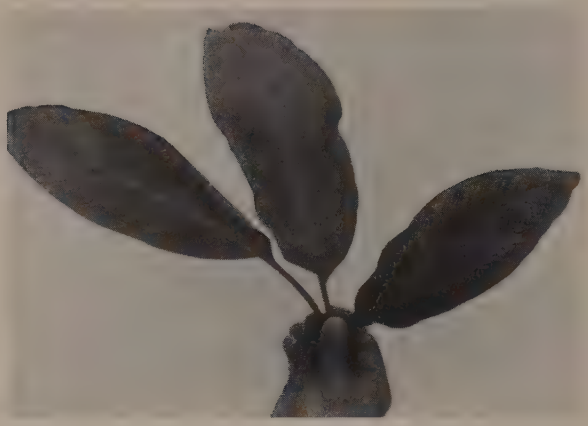


Fig. 1. Showing early symptoms of mosaic (strain 1) in a young abaca seedling. The first symptom leaf is on the left and the other two leaves are in the order in which they followed this leaf. Note the slight reduction in size of the third leaf and its shorter leaf stalk.

Fig. 2. Similar to *Fig. 1* except that in addition to yellowish dots and spindle-shaped streaks, diffused-yellowish areas also occur.

Fig. 3. Showing early symptoms of mosaic caused by strain 2. The first symptom leaf is the one on the top right and was followed by the severely mottled central leaf. Note the slight "shock" effect of the virus in reducing the size of the central leaf and the length of its leaf stalk.

Fig. 4. Showing first symptoms of latent-primary infections as dark brown to black areas or elongated streaks in the leaf stalk and midrib. No sign of abnormality visible from the upper surface is present in the leaf blade or lamina.

Fig. 5. Illustrating the typically mild onset of the disease in the case of latent-primary infection. This plant was 8 months old and consists of two stalks. First symptoms appeared in the plant in the front in the midrib of the leaf on which the hat rests. All parts of the next leaf were free from symptoms. The third leaf above showed yellow areas and streaks on the leaf stalk and midrib, and spindle shaped yellowish streaks and flecks in the lamina. Note there is no apparent check to growth.

Fig. 6. A hill, 13 months' old, in which latent primary infection showed up first in four suckers, when the hill was 12 months old. The two main plants were still healthy.

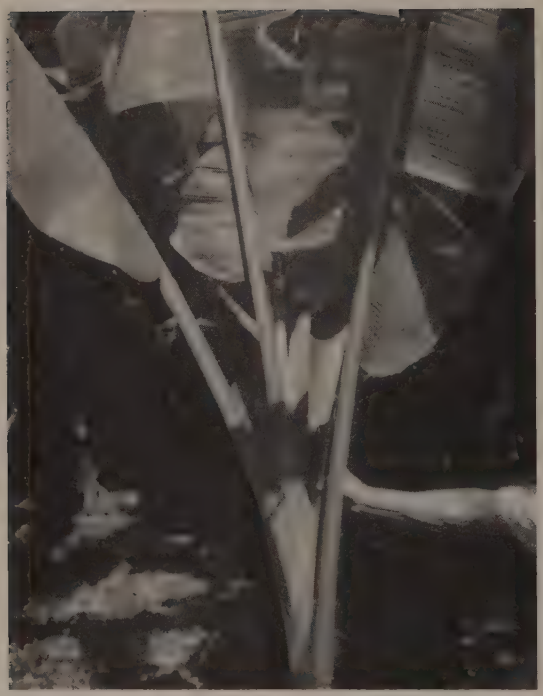


Fig. 7. Showing apex of a plant, 18 months old, in which symptoms had only recently appeared as a latent-primary infection.

Fig. 8. Hill of Tangongon lawaan in a 3 years old plantation at Taguno which was developed in spite of being surrounded on all sides by maize plantings.

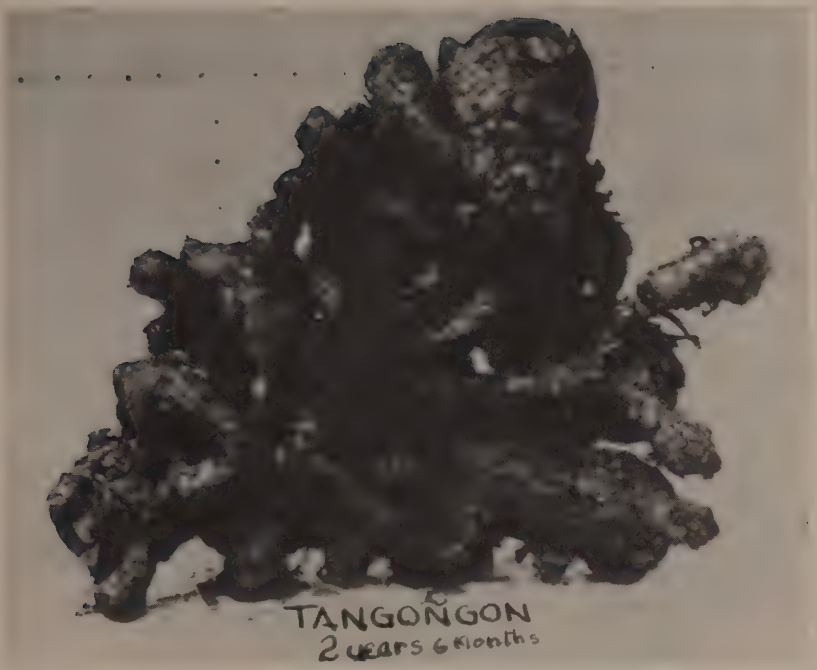


Fig. 9. Illustrating the intricate maize system of abaca which makes it inadvisable to gamble on one clump of satlks being separated from another.

Fig. 10. Showing a 10 months' old cover crop of *Pueraria* at the Southern Mindanao Regional Station that has smothered and choked out all growth of grass weeds. The cover crop was planted about 3 months before the young abaca.

Fig. 11. In Australia and North Borneo, diseased and unwanted banana and abaca plants are destroyed by injecting into each stalk 1/2 fl. oz. of 1 percent 2,4-D through a hollow steel needle. Illustration shows how a pressure pump provided with a long hose and a long steel needle can be converted into a hormone injector.

FIGURE 12. THE SPREAD OF ABACA MOSAIC IN A 3-YEAR OLD PLANTATION, SHOWING THE INITIAL INFECTION AFTER 290 DAYS (AFTER CASTILLO, AGATI AND OTANES).

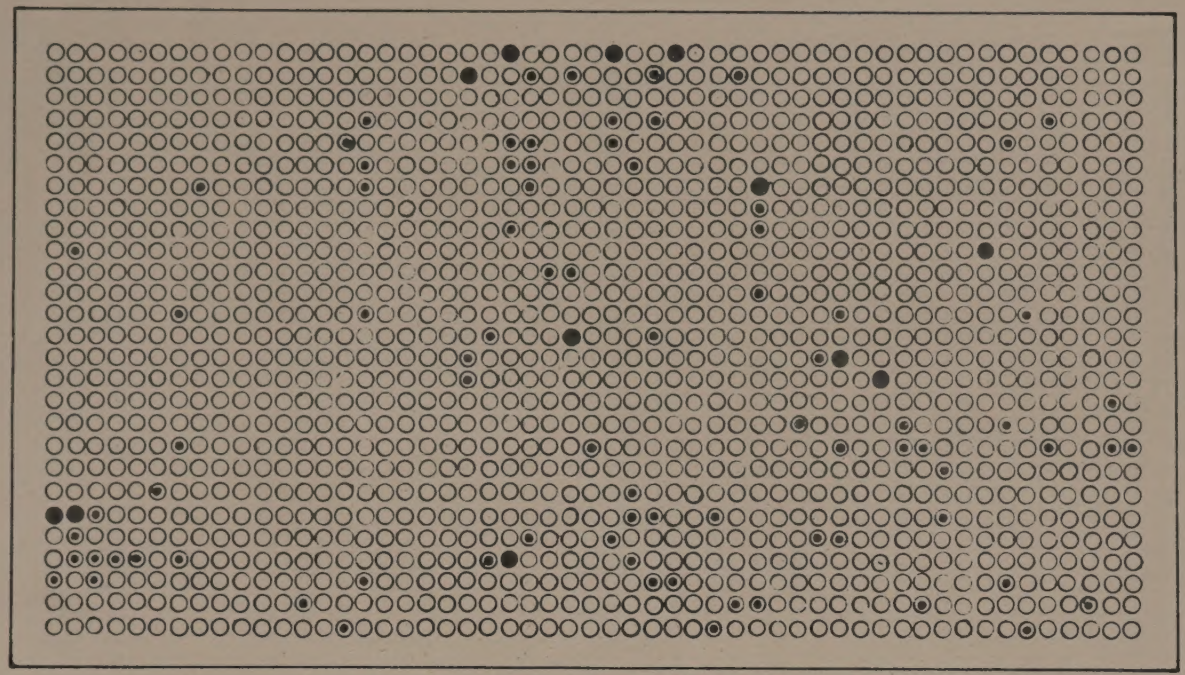
Name of Planter: Elias Dacudao

Locality: Lasang, Davao City

Age of Plantation: 3 Years Old

Date eradicated: April 25, 1951

Date charted: February 8, 1952



LEGEND:

⊙ - Initial infection, 5.80%

● - Subsequent infection after 290 days, 0.91%

○ - Healthy

After Castillo, Agati and Otanes
With Above Reference

C-1095

E.G. Adriano 12-17-56